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6 CAST FILM COOLING METHOD

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8 CROSS-REFERENCE TO RELATED APPLICATIONS

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10 The present application is a division of U. S. ser. No. 09/560,491, filed  
11 April 28, 2000, which application is incorporated herein by reference.  
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13 BACKGROUND OF THE INVENTION

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15 1. Field of the Invention

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17 The current invention concerns an enhanced fluid operated pinning and  
18 cooling assist device and method used for the production of thermoplastic film by  
19 the cast film process.  
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21 2. Prior Art

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23 It has long been recognized that better contact between the molten web  
24 and the chilled casting roll used to produce thermoplastic film by the cast film  
25 process results in better web cooling rates, improved production rates, improved

1 properties dependant upon a fast cooling rate, and improved uniformity of gauge  
2 of the resulting film. To promote better contact between the molten web and  
3 chilled cooling roll numerous devices have been tried, all successful to a greater  
4 or lesser degree, to pin the melt curtain to the casting roll and/or eliminate or  
5 minimize the layer of air trapped between the melt curtain and the casting roll.

6  
7 Initially, some forms of electrostatic pinning devices were used to secure  
8 the web to the chill roll. In U.S. Patent No. 3,102,302 a full width electrode for  
9 pinning the web to the chill roll is disclosed and claimed, while on the other hand  
10 U. S. Patent No. 3,223,757 discloses and claims an electrostatic devices for  
11 pinning the edges of the web to the chill roll. Eventually, however, increasing web  
12 speeds revealed shortcomings to the electrostatic pinning devices; as web  
13 speeds increased the tendency to entrain air between the web and the chill roll  
14 also increased.

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16 To overcome this high-speed air entrainment problem other types of  
17 devices were introduced. Typically, these devices move air either at or away from  
18 the roll and melt curtain. One of the first such devices was an air knife as shown  
19 in U. S. Patent No. 4,874,571. This device delivers a linear stream of air against  
20 the melt curtain at or near the location at which the melt curtain strikes the chilled  
21 casting roll, thereby forcing entrapped air from between the melt curtain and the  
22 casting roll surface. Additionally, vacuum boxes designed to pull air away from  
23 the melt curtain/roll surface interface, i.e. from under the web, as shown in U.S.  
24 Patent No. 4,310,295 were also used. To further improve contact between the  
25 web curtain and the chill roll, another device, hereinafter referred to as a soft box,

1 was eventually introduced. The soft box approached the problem of improving  
2 contact by directing a diffuse stream of pressurized air over the web curtain.  
3 Unlike a conventional air knife, however, which delivers the air stream essentially  
4 in a linear pattern, the stream from the soft box is more diffuse and is applied  
5 over a significant portion of the roll circumference. See U. S. Patent No.  
6 5,091,134 for one configuration of what is herein referred to as a soft box.  
7

8 While the soft box has resulted in improvements in rate of film production  
9 and heat transfer related properties of the resulting film such as clarity, it has also  
10 inadvertently resulted in a reduction in film gauge uniformity. Specifically, the  
11 problem with reduced gauge uniformity appears to be related to flutter introduced  
12 into the web in the unsupported span between the die and the chill roll by air  
13 escaping from the soft box. It is therefore an object of the present invention to  
14 provide an enhanced cooling device for cast film production which will eliminate  
15 the problems associated with air discharge from conventional soft boxes. It is still  
16 another object of the present invention to provided an improved cooling device  
17 for cast film production which will result in higher production rates for cast film  
18 than heretofore seen while improving or at least maintaining acceptable gauge  
19 performance.  
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## 21 SUMMARY OF THE INVENTION 22

23 In accordance with the present invention, there is a new cooling apparatus  
24 for cast film comprising a first plenum for supplying a diffuse stream of air to the  
25 surface of a melt curtain on a casting roll and a second plenum for producing a

1 directional source of pressurized air so located as to discharge pressurized air  
2 into the air discharge stream from the upper portion of the first plenum whereby  
3 the air discharge from the first plenum does not strike and induce flutter in the  
4 melt curtain between the die and the chill roll.

## 5 6 BRIEF DESCRIPTION OF DRAWINGS

7  
8 Fig. 1 shows a cast film die and stand incorporating the cooling device of  
9 the present invention.

10 Fig. 2 shows a cutaway view of the cooling device according to the  
11 present invention.

12 Fig. 3 shows a detailed view of the linear air discharge nozzle used in the  
13 present invention.

14 Fig. 4 shows a schematic view of the airflow from the cooling device over  
15 the casting roll and web.

## 16 17 DESCRIPTION OF THE PREFERRED EMBODIMENT

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19 As shown in Fig. 1, melt curtain 1 is extruded from slot die 2 onto  
20 casting roll 3. A vacuum box 4 of typical construction is located adjacent to but  
21 against the direction of rotation from the point at which melt curtain 1 strikes the  
22 surface of casting roll 3. Vacuum box 4 is used to evacuate air from between  
23 melt curtain 1 and surface of casting roll 2 to provide better heat transfer from  
24 melt curtain 1 to casting roll 3. Following melt curtain 1 in the direction of rotation  
25 of casting roll 3 from the location at which it strikes casting roll 3 is the cooling

1 device 10 which is the subject of the present invention. As shown in this Fig. 1,  
2 there are two major assemblies, a first plenum assembly 20 and a second  
3 plenum assembly 30. Each plenum assembly 20 and 30 is provided with its own  
4 source of pressurized air, 7 and 8, which typically will be a centrifugal blower.  
5 Additionally, as shown in Fig. 1, plenum 20 partially overlies casting roll 3 and  
6 melt curtain 1, as side pieces 25 and 25' of first plenum assembly 20 project  
7 inwardly and parallel to the ends of casting roll 3. For purposes of future  
8 reference, a tangent to the surface of casting roll 3 at the point at which air  
9 discharged from second plenum assembly 30 strikes roll 3 is identified as 50.  
10

11  
12 The cooling device 10 of the present invention is shown in detail in Fig. 2.  
13 There is a first plenum assembly 20 having an air inlet 21, a back wall 22, a top  
14 piece 23, a bottom piece 24, two end pieces 25 and 25', and a discharge side 27.  
15 Additionally, there is a perforated diffuser 26 situated between back wall 22 and  
16 the discharge side 27. Discharge side 27 is open, and in operation will be  
17 adjacent to cooling roll 3 and web 1 which lies on cooling roll 3. The relationship  
18 between cooling roll 3, web 1 and discharge side 27 can be seen most clearly in  
19 Figs. 1 and 4. Immediately above the first plenum assembly 20 is a second  
20 plenum assembly 30. Second plenum assembly 30 has an air inlet 31 and a body  
21 assembly 32 having a tubular back wall 33, a top piece 34, a bottom piece 35,  
22 two end pieces 36 and 36', and a linear discharge nozzle 37. In the preferred  
23 embodiment as shown in Fig.2, tubular back wall 33 will also serve to distribute  
24 air to the inside of the plenum and will comprises a heavy walled pipe to which  
25 top piece 34 and bottom piece 35 are attached. Tubular back wall 33 has been

1 perforated between the points of attachment of top piece 34 and bottom piece  
2 35.

3  
4 Fig. 3 shows the detailed structure of discharge nozzle 37, and its  
5 relationship to top piece 23 of first plenum assembly 20, casting roll 3, web 1,  
6 and the discharge path 29 for air from first plenum assembly 20. Second plenum  
7 assembly 30 is mounted directly onto the top piece 23 of first plenum assembly  
8 20. Mounted on top piece 34 of second plenum assembly 30 is an adjustable  
9 blade 38. An air discharge nozzle 37 is defined between the inboard end 35' of  
10 bottom piece 35 and the adjustable blade 38. Adjustable blade 38 is mounted to  
11 top piece 34 by mounting block 39. Any conventional means may be used to  
12 mount blade 38 to top piece 34 that will allow some movement of adjustable  
13 blade 38 with respect to bottom piece 35. In practice it has been found that  
14 mounting block 39 to mounting top piece 34 with simple machine screws,  
15 wherein the screw holes in mounting block 39 are elongated is satisfactory.

16  
17 Fig. 3 also shows the relationship between the discharge zones for the  
18 first plenum and the second plenum. As shown, the discharge from the linear  
19 nozzle 37 of the second plenum discharges directly into the upper discharge  
20 stream of the first plenum. This upper discharge stream for first plenum assembly  
21 20 is defined by top piece 23, sidepieces 25 and 25', and the outer surface of  
22 casting roll 3 and melt 1. As shown in Fig. 3, the orientation of adjustable blade 38  
23 is intended to strike tangent 50 on cooling roll 3 at an angle of approximately 30  
24 degrees.

1           Fig. 4 shows the directions of airflows associated with the present  
2 invention. Melt curtain 1 is initially struck by a linear discharge from nozzle 37 of  
3 second plenum assembly 30 and forced against casting roll 3. Melt curtain 1 is  
4 then further forced onto the surface of casting roll 3 by the diffuse air discharge  
5 from first plenum assembly 20. As shown in Fig. 4 and as previously discussed  
6 in conjunction with Fig. 3, air discharged from nozzle 37 is directed into the  
7 opening at the upper surface of first plenum assembly 20 formed by casting roll 3  
8 and melt curtain 1, side pieces 25 and 25' and top piece 23. This air stream  
9 discharged from nozzle 37 deflects air discharged from the first plenum assembly  
10 20 that would normally be expected to escape through this opening and redirects  
11 the flow along the direction of rotation of casting roll 3. The net effect of the air  
12 discharges from nozzle 37 and first plenum assembly 20 is to press melt curtain  
13 1 tightly to casting roll 3 while substantially limiting the air discharge from first  
14 plenum assembly 20 from striking melt curtain 1 between die 2 and the location  
15 at which it strikes casting roll 3. As previously indicated, flutter or other motion of  
16 melt curtain 1 in the region between die 2 and casting roll 3 induced by air  
17 escape results in gauge variations in the finished film. It is customary for the air  
18 discharged from both the first and second plenums to be at ambient temperature;  
19 for certain applications, however, an improvement in rate may further be seen if  
20 the air discharged from the first plenum is cooled below ambient temperature.

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22           By way of example, the current invention was tested on the production of  
23 multi-layer polypropylene film. The polypropylene film had a finished width of  
24 4300 mm and a nominal thickness of 20 microns. The film was extruded at a rate  
25 of 1000 Kg per hour. Air pressures in the first and second plenums exceeded .5

1 inches of water, and preferably were in the range of 2 to 3 inches of water and 5  
2 to 10 inches of water respectively. Film thickness measurements made on line  
3 with an NDC Beta gauging system showed a maximum film thickness variation  
4 across the web of 1.5%.

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6 Although the invention has been illustrated by the production of  
7 polypropylene film, the invention is not to be construed as limited to the  
8 production of propylene film. All manner of thermoplastic film forming resins used  
9 in the cast film process can be processed with the current invention. The  
10 combined flows from both plenums not only reduces flutter between the extrusion  
11 orifice and the chill roll, thereby improving gauge control, but also improves rate  
12 by improved pinning of the web to the casting roll and reduced air entrainment.